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Results of the 2025 intercomparison of passive radon detectors

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APPROVED

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Executive summary

Radon is the largest and most variable contributor of ionising radiation dose to the general population. For more than 40 years, countries in Europe and elsewhere have carried out measurement surveys to determine both individual and average exposures, and to identify where excessive exposures might occur. Most of these measurements have been completed using passive etched track radon detectors exposed for periods of months. Activated charcoal and electret radon detectors have also been used, mainly for shorter term measurements. In addition, all 3 types of detector are used for experimental and research work. Intercomparisons provide information about the accuracy and precision of measurements. By allowing different detectors to be compared side by side to reference radon exposures, an objective assessment can be made. The results of intercomparisons have been used by individual laboratories to identify and rectify problems, as well as providing calibrations for their detectors traceable to international standards. Laboratories are required to participate in "interlaboratory comparisons" to achieve accreditation under ISO/IEC 17025:2017 'General requirements for the competence of testing and calibration laboratories'.

The Radiation, Chemical, Climate and Environmental Hazards Directorate (RCCE) of the UK Health Security Agency (UKHSA), was formerly known as the Centre for Radiation, Chemical and Environmental Hazards (CRCE) of Public Health England (PHE). RCCE carries out international intercomparisons of passive radon detectors each year. For this latest intercomparison, laboratories were invited to submit sets of 60 etched track detectors, 30 electret detectors and/or 15 activated charcoal detectors.

Only etched track detectors and electret detectors were submitted. At RCCE, each set of detectors was randomised into 6 groups – for etched track detectors this was 6 groups of 10 detectors, for electret detectors this was 6 groups of 5 detectors. Five of these groups were exposed in the RCCE radon chamber to radon gas exposures ranging from 160 kBq m^{-3} h to 2,200 kBq m^{-3} h; the 6th group was used to determine transit exposures.

The detectors were then returned to the participating laboratories, which were asked to report the integrated radon gas exposure result for each detector. The laboratories were not informed of the details of the exposures, nor which detectors were in which group, until after the deadline for submission of results for the report.

This report considers the results for the intercomparison carried out in 2025, for which a total of 26 laboratories from 12 countries submitted 30 sets of detectors. Two laboratories each withdrew 1 set of their results and 1 laboratory was unable to provide results - consequently these are excluded from the report.

This report therefore covers 25 laboratories and 27 sets of detectors from 12 countries. The 27 sets of detectors comprise 25 sets of etched track detectors and 2 sets of electret detectors.

Analysis of the results allows each exposure group in each set to be classified from A (best) to F (worst).

Stringent quality assurance is vital, as is consideration of the equipment used and the measurement technique. Although 1 laboratory reported their results to 2 decimal places, these results have been rounded to the nearest whole number for this report.

Introduction

Passive detectors, of varying designs, have been used for many years to make measurements of integrated radon exposures. The 3 most common methods are outlined below:

1. Etched track detectors are referred to as such because alpha particles from radon and its decay products damage the surface of the plastic detection medium, producing microscopic invisible tracks. These tracks are subsequently made visible by chemical or electrochemical etching. The most popular etched track materials are cellulose nitrate (LR-115), polycarbonate (Makrofol®) and polyallyl diglycol carbonate (PADC or CR-39™). In the open type of etched track detector, the plastic material is exposed to the ambient atmosphere and records alpha particles originating from radon decay products and from radon isotopes. For these open detectors, the radioactive decay equilibrium factor, *F*, for radon-222 (^{222}Rn) has to be taken into account to estimate the proportion of alpha particles that arise from ^{222}Rn decay. In the closed type, the detection material is enclosed in a chamber that excludes entry of ambient radon decay products and only allows entry of radon gas by diffusion. The response of closed detectors is not affected by *F*.
2. Electret detectors consist of an air chamber above an electret. Ionisation of air in the chamber by radon gradually discharges the electret. Measurement of the charge on the electret by the laboratory, before and after radon exposure, allows the average radon concentration during exposure to be calculated. A filter in the chamber excludes radon decay products, so the response is unaffected by *F*.
3. Activated charcoal detectors work by retaining adsorbed radon in a charcoal volume. The radon exposure is subsequently measured in the originating laboratory. This measurement must be completed within 3 days of exposure, so only UK laboratories can take part in the intercomparison with these detectors.

Passive radon detectors are quite simple to produce and to process but are subject to various sources of error during production, storage and processing. It is therefore appropriate for laboratories that use these detectors to undertake regular checks against reference exposures carried out in relevant radon exposure facilities.
This intercomparison programme was established by the National Radiological Protection Board (NRPB), now the UKHSA Radiation, Chemical, Climate and Environmental Hazards Directorate (RCCE), in 1982 and has operated annually since 1997. It was developed with broad

international participation, following standard and agreed test and interpretation protocols. It has been designed to provide participants with a routine benchmark performance standard. Operational procedures and equipment have been described previously (1).

Laboratory exposure and measurement facilities

The exposures in this intercomparison were carried out in the UKHSA radon chamber. This 43 m^3 walk-in chamber is of the static type, in which radon is continually released from dry radium-226 (^{226}Ra) radon sources. There is no air flow through the chamber during operation.

The radon concentration in the chamber was continuously monitored using an ATMOS 12 DPX ionisation chamber and with an AlphaGUARD ionisation chamber as a secondary transfer standard. A daily cross-calibration between the ATMOS 12 DPX and AlphaGUARD was carried out throughout the intercomparison exercise. Both instruments are calibrated annually using a radon gas standard source, most recently supplied by Laboratoire National Henri Becquerel, France.

There were no open detectors submitted, therefore the radon decay products were not sampled and measured. All chamber-monitored data were automatically transferred to a database. Radon exposures were calculated subsequently.

Logistical arrangements

In total, 26 laboratories from 12 countries took part in the 2025 UKHSA intercomparison. Some laboratories submitted more than 1 set of detectors, so 30 sets of detectors were exposed in the radon chamber. Following exposure, the detectors were returned to the originating laboratories for processing. Two laboratories each withdrew 1 set of their results and 1 laboratory did not provide results so these could not be included in the report.

This report therefore covers 25 laboratories and 27 sets of detectors from 12 countries, as shown in Table 2. The 27 sets of detectors were 25 sets of etched track detectors and 2 sets of electret detectors.

Participants were asked to return the result for each detector in terms of integrated exposure to radon. The participants were not told any details of the exposures delivered in the exercise until after the results had been received from all the laboratories included in this report.

Radon exposures

Appropriate conditions for typical domestic radon exposure were established in the chamber before introducing the etched track and electret detectors.

The chamber exposures were calculated after the deadline for return of results by participants and are shown with exposure durations in Table 3. Radon concentrations during the etched track and electret detector exposures are shown in Figures 1 to 5.

The radon concentration in the laboratory outside the exposure chamber was monitored during the exposures using an AlphaGUARD ionisation chamber. The laboratory daily average corrected concentrations ranged from 13 Bq m^{-3} to 36 Bq m^{-3}, with an overall average for the exposure period of 25 Bq m^{-3}. The estimated additional exposure of the etched track and electret detectors caused by leaving them exposed in the laboratory for a minimum of 3 days to allow radon to diffuse out, was between 0.14% and 1.2% of the exposure in the chamber. This value was excluded for the purpose of calculating the reference exposures. Transit detectors were used to monitor radon exposures received in transit.

Performance classification scheme

A performance classification scheme was introduced in 2011 (2), based on the following parameters:

- percentage biased error which measures the bias of the measurement
- percentage precision error, which measures the precision of the measurement
- percentage measurement error, which takes into account their combined effect

The measured mean is obtained by subtracting the mean transit exposure from the mean reported exposure. The parameters are given below:

$$\% \text{ biased error} = \frac{(\text{Measured mean} - \text{Reference value})}{\text{Reference value}} \times 100$$

where the reference value is the reference radon exposure,

$$\% \text{ precision error} = \frac{\text{Standard deviation}}{\text{Measured mean}} \times 100$$

$$\% \text{ measurement error} = \sqrt[2]{(\% \text{ biased error}^2 + \% \text{ precision error}^2)}$$

Since the percentage measurement error combines the biased error and precision error, a result can have low measurement error only if both bias and precision errors are low. Measurement errors are reflected as a performance classification from A (best) to F (worst) for each exposure separately. Each participating laboratory was assigned a classification, between A and F, for each exposure. The criteria for each of the classification groups are given in Table 1:

Table 1. Performance classification

Range of measurement error (%)	Performance classification
less than 10%	A
greater than or equal to 10% and less than 20%	B
greater than or equal to 20% and less than 30%	C
greater than or equal to 30% and less than 40%	D
greater than or equal to 40% and less than 50%	E
greater than or equal to 50%	F

Results and discussion

The results reported by the laboratories for the etched track and electret detectors are given in Tables 4.1 to 4.6. The tables show the results for 25 laboratories and a total of 27 sets of detectors.

In Tables 4.1 to 4.5, the ‘mean’ is the mean result of 10 exposed detectors (5 for electrets) after subtracting the mean transit exposure. The standard deviation, ‘1 SD’, is for 10 reported results (5 for electrets). Results for % biased error, % precision error and % measurement error are also provided.

The mean results and their standard deviations, as reported by participants, are depicted in Figures 6 to 10; the reference exposures are indicated by dotted lines. The mean of all transit exposures is shown in Figure 11.

The mean and standard deviation of all reported results, calculated for each exposure, are given in Table 5. The distributions of the mean exposure results given in Table 5 are depicted in Figures 12 to 17. For Figures 12 to 16, the reference exposures are indicated by vertical dotted lines.

The characteristics of the detectors such as material, detector holder design, detector type and material supplier are provided in Table 6.
The mean of all transit exposures was 27 kBq m^{-3} h (Figure 11). A total of 22 reported transit exposures were below 40 kBq m^{-3} h, 4 reported transit exposures between 40 kBq m^{-3} h and 205 kBq m^{-3} h, of which 3 of these were below 62 kBq m^{-3} h. This range of results is similar to those in 2024 (3) where 5 out of a total of 27 reported transit exposures were between 40 kBq m^{-3} h and 95 kBq m^{-3} h, of which 3 were below 60 kBq m^{-3} h.

The results, using the performance classification scheme, are given in Table 6. This table is sorted according to performance classification with the first order of sort being the lowest exposure. The position of a laboratory in the table reflects the performance classification of the different exposures and should not be interpreted as a criterion of their total performance. The results in the table are informative and can be used by laboratories to review their procedures and to identify problems at different exposure levels.

A total of 8 laboratories achieved class A results for all 5 exposures in a set, meaning that they have a measurement error of under 10% for all 5 exposures. This is 4 fewer laboratories than in 2024.

Approximately 67% of all sets of detectors achieved class A for at least 3 exposures, which is the same as in 2024. (3). For the lowest exposure measurement (167 kBq m^{-3} h), 37% of laboratories achieved class A, a decrease compared to 2024. For the second lowest exposure (431 kBq m^{-3} h), 67% of laboratories achieved class A, which is the same as in 2024.

It should be noted that the laboratories participating with the same type of detectors and detector material can achieve quite different performance classifications, possibly reflecting each laboratory's own quality assurance (QA) protocols and staff experience.

To identify sources of errors, the laboratories should take into account changes in various parameters such as calibration factor, sensitivity and background (4). Reviews of sources of errors for etched track detectors are given in references (5), (6) and (7). Constant monitoring of detector performance and strict QA protocols should be established and maintained to identify and manage the above sources of errors.

The storage methods used by the laboratories were: in a freezer, in a freezer in radon-proof bags; in a low radon storage room; only in radon-proof bags; in a cabinet continually flushed with nitrogen; in radon-proof bags in a cabinet continually flushed with nitrogen; stored in a unit with carbon-filtered pressurised air. Most laboratories use a freezer. The maximum storage time before use ranged from 15 days to up to 10 years. One laboratory had no maximum storage time – the background radon level of the material is checked every 3 months and before it is put into use. Of the sets that had a transit exposure less than 50 Bq m^{-3} h, most (18 out of 23) were sent using radon proof bags. Of the 3 sets where the transit exposure was at or above 50 Bq m^{-3} but below 100 Bq m^{-3}, two of the sets were sent using 'radon proof' bags and the

storage (in a freezer) ranged from 1 year to 10 years. The other set was sent using plastic bags, with storage in a low radon room for up to 1 year. One set with a transit exposure above 100 Bq m^{-3} was not sent in radon-resistant packaging and no storage details were given. This range of transit results indicates that other factors apply – this may include the radon resistance of some 'radon-proof' bags, the etching methods used, ageing of the plastic and staff training. The proportion of sets achieving each performance classification (A to F) is given in Figure 18.

Conclusions

In total, 26 laboratories from 12 countries participated in the 2025 UKHSA intercomparison.

One laboratory did not send their results, so could not be included in the report and 2 other laboratories each withdrew 1 set of results. This report is for 25 laboratories and 27 sets of detectors from 12 countries. The detectors were 25 sets of etched track detectors and 2 sets of electret detectors.

A 6-band (A to F) classification scheme was used to evaluate the performance of the detectors across a range of exposures. A total of 8 laboratories achieved 5 class A ratings, which is a 4 fewer than in the 2024 intercomparison.

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7. Hardcastle GD and Miles JCH. 'Ageing and fading of alpha particle tracks in CR-39 exposed to air'. Radiation Protection Dosimetry 1996: volume 67, issue 4, pages 295-298

Tables and figures

Table 2. Participating laboratories

Contact person	Organisation	Country
Nivaldo Carlos da Silva	Brazilian Commission for Nuclear Energy (CNEN)	Brazil
Jussi-Pekka Laine / Tiina Oinas	Radiation and Nuclear Safety Authority (STUK)	Finland
Dorian Guyot	PearL	France
David Doyle	Alpharadon Ltd.	Ireland
Silvia Bucci / Gabriele Pratesi / Matteo Archimi / Massimo Guazzini	ARPAT - Agenzia Regionela per la protezione ambientale della Toscana	Italy
Silvia Penzo / Fabio Alessio Vittoria / Giuseppe Leopizzi	ENEA	Italy
Simona Rullo	Gaia Consulting& Technologies Srl	Italy
Dr. Massimo Moroni	Harmat srls	Italy
Sotgiu AM / Hazm Hassan Awad N / Ascenzi C / Magro L	National Inspectorate for nuclear safety and radiation protection ISIN	Italy
Andrea Fascendini	NOradon srl	Italy
Dr. Claudio Cazzato	Radongas srl	Italy
Massimo Esposito / Serena Sanna / Simone Stefanini	WhiteLab Srl - U-Series	Italy
Marielle Lecomte	Division de la Radioprotection	Luxembourg
Maja Grøttum	Norwegian Radiation and Nuclear Safety Authority (DSA)	Norway
Matija Škrlep	ZVD d.o.o.	Slovenia
Dr. Rian Strydom	PARC RGM	South Africa
Victoria Moreno	A10RADO, SL	Spain
Ismael Fuente / Santiago Celaya	LaRUC - University of Cantabria	Spain
Alberto Otero Pazos	LRA-UDC	Spain
Gilbert Jönssen	Radonanalys GJAB	Sweden
Vanda Jakabová / Tryggve Rönnqvist	Radonova Laboratories AB	Sweden
Gary Moss	Radosure	United Kingdom
Julie Cowlin	Testair Ltd.	United Kingdom
Maddy Gibbs	UKHSA Personal Dosimetry	United Kingdom
Dr. Jaroslaw Wasikiewicz	UKHSA Radon Dosimetry	United Kingdom

Table 3. Exposure parameters – etched track and electret detectors

Exposure	1	2	3	4	5
Duration (h)	165.05	39.97	265.48	484.18	103.18
Radon exposure (kBq m^{-3} h)	740	167	1185	2135	431
Uncertainty (%) at 68% Confidence Level	3.0	3.0	3.0	3.0	3.0

Table 4.1. Analysis of all reported results for etched track and electret detectors: Exposure 1, 740 kBq m^{-3} h, etched track and electret detectors

Set ID	Mean (kBq m^{-3} h)	1 SD (kBq m^{-3} h)	% biased error	% precision error	% measurement error
1-1	801.5	23.0	8.3	2.9	8.8
5-1	695.1	27.9	-6.1	4.0	7.3
13-1	758.1	45.4	2.4	6.0	6.5
13-2	782.1	21.6	5.7	2.8	6.3
20-1	812.9	24.6	9.9	3.0	10.3
21-1	750.9	40.7	1.5	5.4	5.6
32-1	757.1	35.8	2.3	4.7	5.3
40-1	1028.3	623.3	39.0	60.6	72.1
49-1	751.7	28.0	1.6	3.7	4.0
54-2	798.2	54.3	7.9	6.8	10.4
62-1	879.9	52.3	18.9	5.9	19.8
134-1	830.8	88.5	12.3	10.7	16.2
136-1	700.3	12.1	-5.4	1.7	5.6
141-1	798.2	18.5	7.9	2.3	8.2
141-2	840.4	13.4	13.6	1.6	13.7
156-1	775.3	32.5	4.8	4.2	6.4
160-1	745.4	34.4	0.7	4.6	4.7
171-1	671.0	142.2	-9.3	21.2	23.2
173-1	694.8	13.4	-6.1	1.9	6.4
177-1	751.1	20.4	1.5	2.7	3.1
196-1	733.7	18.2	-0.9	2.5	2.6
197-1	705.5	21.0	-4.7	3.0	5.5
198-1	806.1	27.7	8.9	3.4	9.6
207-1	644.3	270.0	-12.9	41.9	43.9
209-1	901.5	3.1	21.8	0.3	21.8
212-1	753.0	50.7	1.8	6.7	7.0
213-1	674.3	16.9	-8.9	2.5	9.2

Table 4.2. Analysis of all reported results for etched track and electret detectors: Exposure 2, 167 kBq m^{-3} h, etched track and electret detectors

Set ID	Mean (kBq m^{-3} h)	1 SD (kBq m^{-3} h)	% biased error	% precision error	% measurement error
1-1	190.7	10.1	14.2	5.3	15.1
5-1	155.4	8.5	-6.9	5.5	8.8
13-1	175.7	19.6	5.2	11.2	12.3
13-2	180.1	7.0	7.8	3.9	8.8
20-1	187.2	10.6	12.1	5.7	13.4
21-1	179.0	16.9	7.2	9.4	11.9
32-1	163.9	14.7	-1.9	9.0	9.2
40-1	179.7	30.1	7.6	16.8	18.4
49-1	172.7	19.1	3.4	11.1	11.6
54-2	196.9	37.4	17.9	19.0	26.1
62-1	198.9	19.5	19.1	9.8	21.5
134-1	286.2	58.6	71.4	20.5	74.3
136-1	154.6	2.8	-7.4	1.8	7.6
160-1	168.7	11.1	1.0	6.6	6.7
171-1	170.3	33.8	2.0	19.8	19.9
173-1	173.8	6.4	4.1	3.7	5.5
177-1	169.9	12.4	1.7	7.3	7.5
196-1	159.7	5.0	-4.4	3.1	5.4
197-1	156.9	14.1	-6.0	9.0	10.8
198-1	182.8	14.3	9.5	7.8	12.3
207-1	146.4	142.7	-12.3	97.5	98.3
209-1	203.7	2.5	22.0	1.2	22.0
212-1	132.5	26.6	-20.7	20.1	28.8
213-1	149.5	12.4	-10.5	8.3	13.4

Table 4.3. Analysis of all reported results for etched track and electret detectors: Exposure 3, 1185 kBq m^{-3} h, etched track and electret detectors

Set ID	Mean (kBq m^{-3} h)	1 SD (kBq m^{-3} h)	% biased error	% precision error	% measurement error
1-1	1234.8	35.7	4.2	2.9	5.1
5-1	1097.5	28.3	-7.4	2.6	7.8
13-1	1184.8	56.9	0.0	4.8	4.8
13-2	1234.3	47.8	4.2	3.9	5.7
20-1	1294.5	27.4	9.2	2.1	9.5
21-1	1172.6	59.2	-1.0	5.0	5.2
32-1	1187.1	33.1	0.2	2.8	2.8
40-1	1391.0	271.7	17.4	19.5	26.1
49-1	1181.3	37.3	-0.3	3.2	3.2
54-2	1213.4	106.2	2.4	8.8	9.1
62-1	1319.8	100.3	11.4	7.6	13.7
134-1	1323.0	71.3	11.6	5.4	12.8
136-1	1120.8	21.3	-5.4	1.9	5.7
141-1	1229.6	13.7	3.8	1.1	3.9
141-2	1319.4	23.8	11.3	1.8	11.5
156-1	1267.1	48.9	6.9	3.9	7.9
160-1	1189.8	23.8	0.4	2.0	2.0
171-1	1097.7	170.9	-7.4	15.6	17.2
173-1	1134.6	26.3	-4.3	2.3	4.8
177-1	1205.4	19.2	1.7	1.6	2.3
196-1	1144.6	25.7	-3.4	2.2	4.1
197-1	1183.2	37.6	-0.2	3.2	3.2
198-1	1258.4	31.7	6.2	2.5	6.7
207-1	1113.9	153.4	-6.0	13.8	15.0
209-1	1412.7	5.5	19.2	0.4	19.2
212-1	1199.0	46.0	1.2	3.8	4.0
213-1	1059.2	32.8	-10.6	3.1	11.1

Table 4.4. Analysis of all reported results for etched track and electret detectors: Exposure 4, 2135 kBq m^{-3} h, etched track and electret detectors

Set ID	Mean (kBq m^{-3} h)	1 SD (kBq m^{-3} h)	% biased error	% precision error	% measurement error
1-1	1987.0	41.1	-6.9	2.1	7.2
5-1	1976.3	34.7	-7.4	1.8	7.6
13-1	2234.4	65.7	4.7	2.9	5.5
13-2	2350.1	65.4	10.1	2.8	10.5
20-1	2331.5	43.4	9.2	1.9	9.4
21-1	2116.6	58.5	-0.9	2.8	2.9
32-1	2015.9	119.6	-5.6	5.9	8.1
40-1	2826.4	793.7	32.4	28.1	42.9
49-1	2058.9	49.2	-3.6	2.4	4.3
54-2	2199.6	190.8	3.0	8.7	9.2
62-1	2197.5	124.0	2.9	5.6	6.4
134-1	2378.4	161.9	11.4	6.8	13.3
136-1	2060.0	44.8	-3.5	2.2	4.1
141-1	2299.1	47.2	7.7	2.1	8.0
141-2	2451.2	42.0	14.8	1.7	14.9
156-1	2178.5	64.6	2.0	3.0	3.6
160-1	2176.6	44.2	1.9	2.0	2.8
171-1	1857.6	152.0	-13.0	8.2	15.4
173-1	1987.8	39.2	-6.9	2.0	7.2
177-1	2204.7	49.6	3.3	2.2	4.0
196-1	2075.6	21.3	-2.8	1.0	3.0
197-1	2076.2	53.6	-2.8	2.6	3.8
198-1	2229.4	37.0	4.4	1.7	4.7
207-1	1897.3	285.8	-11.1	15.1	18.7
209-1	2705.1	31.9	26.7	1.2	26.7
212-1	2122.1	50.4	-0.6	2.4	2.5
213-1	1884.0	47.9	-11.8	2.5	12.0

Table 4.5. Analysis of all reported results for etched track and electret detectors: Exposure 5, 431 kBq m^{-3} h, etched track and electret detectors. See Figure 10.

Set ID	Mean (kBq m^{-3} h)	1 SD (kBq m^{-3} h)	% biased error	% precision error	% measurement error
1-1	463.6	29.4	7.6	6.3	9.9
5-1	393.9	13.9	-8.6	3.5	9.3
13-1	435.1	31.3	1.0	7.2	7.3
13-2	447.4	17.1	3.8	3.8	5.4
20-1	467.6	18.1	8.5	3.9	9.3
21-1	435.0	20.9	0.9	4.8	4.9
32-1	417.7	35.4	-3.1	8.5	9.0
40-1	481.3	48.9	11.7	10.2	15.5
49-1	435.5	38.0	1.0	8.7	8.8
54-2	484.9	24.4	12.5	5.0	13.5
62-1	517.4	31.4	20.0	6.1	20.9
134-1	511.8	58.4	18.7	11.4	21.9
136-1	397.5	8.0	-7.8	2.0	8.0
141-1	467.3	6.4	8.4	1.4	8.5
141-2	477.4	26.8	10.8	5.6	12.1
156-1	467.8	19.9	8.5	4.3	9.5
160-1	426.5	16.8	-1.0	3.9	4.1
171-1	462.7	87.9	7.4	19.0	20.4
173-1	425.0	13.1	-1.4	3.1	3.4
177-1	438.5	10.8	1.7	2.5	3.0
196-1	425.3	8.8	-1.3	2.1	2.5
197-1	422.7	14.6	-1.9	3.5	4.0
198-1	456.0	24.7	5.8	5.4	7.9
207-1	351.4	234.7	-18.5	66.8	69.3
209-1	511.6	2.6	18.7	0.5	18.7
212-1	453.3	24.1	5.2	5.3	7.4
213-1	387.7	8.2	-10.0	2.1	10.3

Table 4.6. Analysis of all reported results for etched track and electret detectors: Transit exposure, etched track and electret detectors, see Figure 11.

Set ID	Mean (kBq m^{-3} h)	1 SD (kBq m^{-3} h)
1-1	**1.8**	**1.6**
5-1	**20.3**	**11.3**
13-1	**5.6**	**6.0**
13-2	**6.9**	**4.0**
20-1	**9.5**	**3.6**
21-1	**10.0**	**5.7**
32-1	**24.3**	**6.9**
40-1	**6.5**	**3.2**
49-1	**9.1**	**5.5**
54-2	**27.7**	**5.1**
62-1	**12.6**	**1.7**
134-1	**29.8**	**7.6**
136-1	**52.1**	**2.2**
141-1	**24.6**	**6.1**
141-2	**18.0**	**12.5**
156-1	**8.4**	**4.9**
160-1	**40.8**	**5.7**
171-1	**61.7**	**28.3**
173-1	**8.7**	**1.4**
177-1	**7.0**	**4.3**
196-1	**14.5**	**4.7**
197-1	**18.6**	**4.6**
198-1	**56.7**	**9.4**
207-1	**205.4**	**88.7**
209-1	**8.8**	**4.9**
212-1	**21.1**	**9.6**
213-1	**11.8**	**2.5**

Table 5. Statistical analysis of all reported results given in Tables 4.1 to 4.5

Group	Exposure (kBq m^{-3} h)	Mean of all reported results (kBq m^{-3} h)	Standard deviation of all reported results (kBq m^{-3} h)
1	740	771.9	80.7
2	167	177.2	27.6
3	1185	1213.7	88.7
4	2135	2180.7	228.0
5	431	446.7	39.2

Table 6. Performance classification scheme for all five exposures based on measurement error

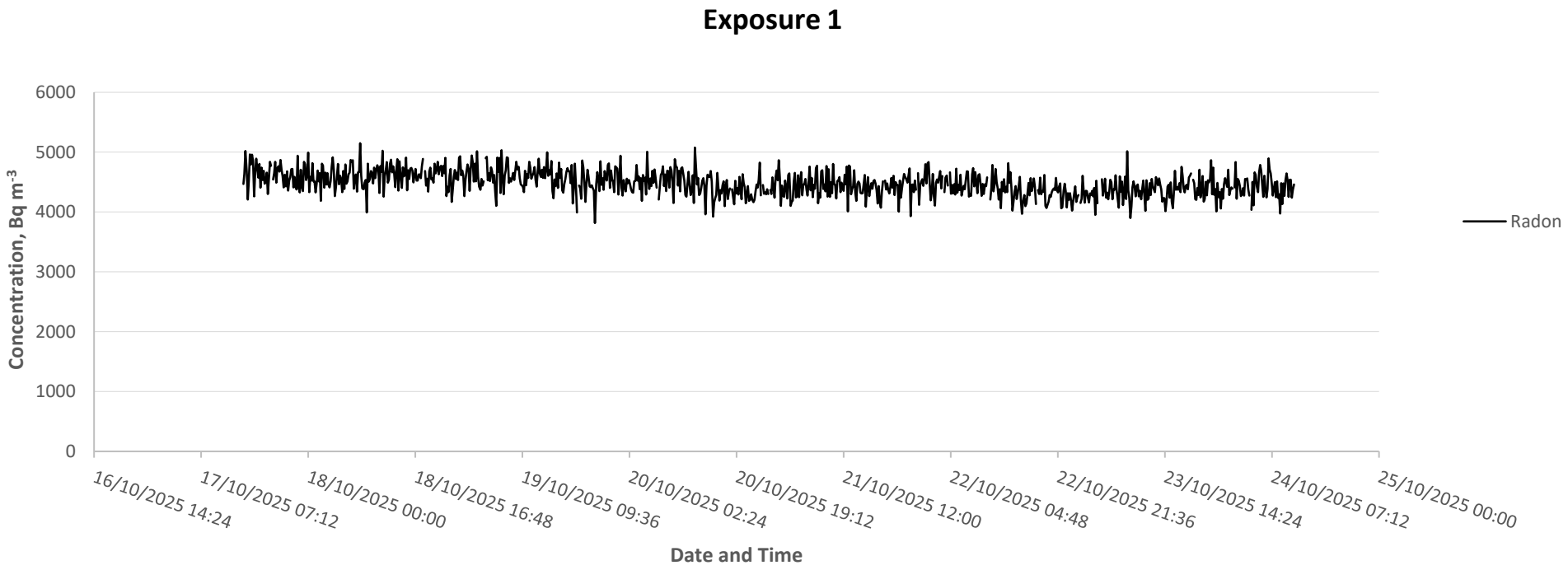
	Exposure 2	Exposure 5	Exposure 1	Exposure 3	Exposure 4	Detector type	Filter	Holder design	Detector material	Detector material supplier
Set ID	167 kBq m^{-3} h	431 kBq m^{-3} h	740 kBq m^{-3} h	1185 kBq m^{-3} h	2135 kBq m^{-3} h					
5-1	A	A	A	A	A	Closed		TASL	CR39	TASL
32-1	A	A	A	A	A	Closed	No	NRPB/SSI	CR39/PADC	TASL
136-1	A	A	A	A	A	Closed	No	NRPB/SSI, Frohe AB - Sweden	PADC	TASL
141-1	A	A	A	A	A	Closed	No	Radosure - TASL	TASTRAK PADC	TASL
160-1	A	A	A	A	A	Closed	No	TASL	CR-39	TASL
173-1	A	A	A	A	A	Closed	Yes	TASL	CR-39	TASL
177-1	A	A	A	A	A	Closed	No	TASL	CR-39	TASL
196-1	A	A	A	A	A	Closed	No	Radout®	PADC	Radonova Scientific Ltd.
1-1	B	A	A	A	A	Closed	No	NRPB	CR-39	Mi-Net
13-1	B	A	A	A	A	Closed	Yes	NRPB/SSI	CR-39	Radonova Scientific Ltd.

Set ID	Exposure 2 167 kBq m^{-3} h	Exposure 5 431 kBq m^{-3} h	Exposure 1 740 kBq m^{-3} h	Exposure 3 1185 kBq m^{-3} h	Exposure 4 2135 kBq m^{-3} h	Detector type	Filter	Holder	Detector material	Detector material supplier
13-2	A	A	A	A	B	Closed	Yes	Radtrak3	CR-39	Radonova Scientific Ltd.
21-1	B	A	A	A	A	Closed	No	ENEA	CR-39	TASL
49-1	B	A	A	A	A	Closed	No	Radosys	CR-39	Radosys
156-1	B	A	A	A	A	Closed	Yes	DSTN - Radosys	CR-39	Radosys
197-1	B	A	A	A	A	Closed	Yes	Radosys	CR-39	Radosys
198-1	B	A	A	A	A	Closed	Yes	TASL	TASTRAK PADC	TASL
212-1	C	A	A	A	A	Closed	No	RSK type diffusion	CR-39	Radosys
20-1	B	A	B	A	A	Closed	No	TASL Radosure	TASTRAK PADC	TASL
54-2	C	B	B	A	A	Closed	Yes	Own design	CR-39	TASL
141-2	A	B	B	B	B	Closed	Yes	S chamber RAD ELEC E-PERM	Electret	Rad-Elec Inc.
213-1	B	B	A	B	B	Closed	No	Radout ® - Mi.am Srl	CR-39	TASL

Set ID	Exposure 2 167 kBq m^{-3} h	Exposure 5 431 kBq m^{-3} h	Exposure 1 740 kBq m^{-3} h	Exposure 3 1185 kBq m^{-3} h	Exposure 4 2135 kBq m^{-3} h	Detector type	Filter	Holder	Detector material	Detector material supplier
62-1	C	C	B	B	A	Closed	No	In-house (sensitive volume 79 ml)	Makrofol®	Covestro
171-1	B	C	C	B	B	Closed	Yes	Own design	LR115	Algade
209-1	C	B	C	B	C	Closed	No	TASL	CR-39	TASL
134-1	F	C	B	B	B	Closed	Yes	S chamber RAD ELEC E-PERM	Electret	Rad-Elec Inc.
40-1*	B	B	F	C	E	Closed	No	NRPB	PADC	Mi-Net Technology Ltd./ Instrument Plastics
207-1	F	F	E	B	B	Closed	No		PADC	Radosys

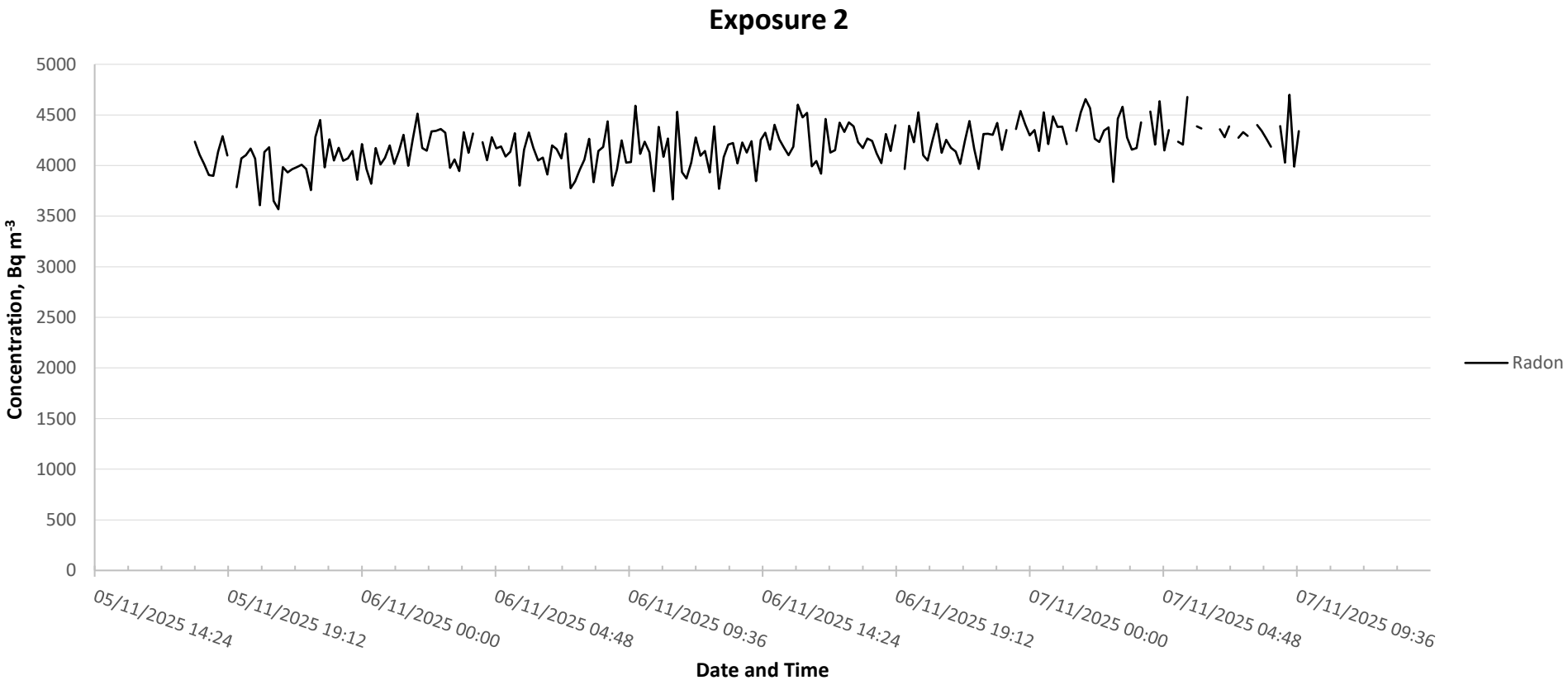
*For 40-1, there was a record-keeping error, where the same detector number was recorded twice. Without this error, the ranking would have been B B C C E.

Figure 1. Radon concentrations for exposure 1



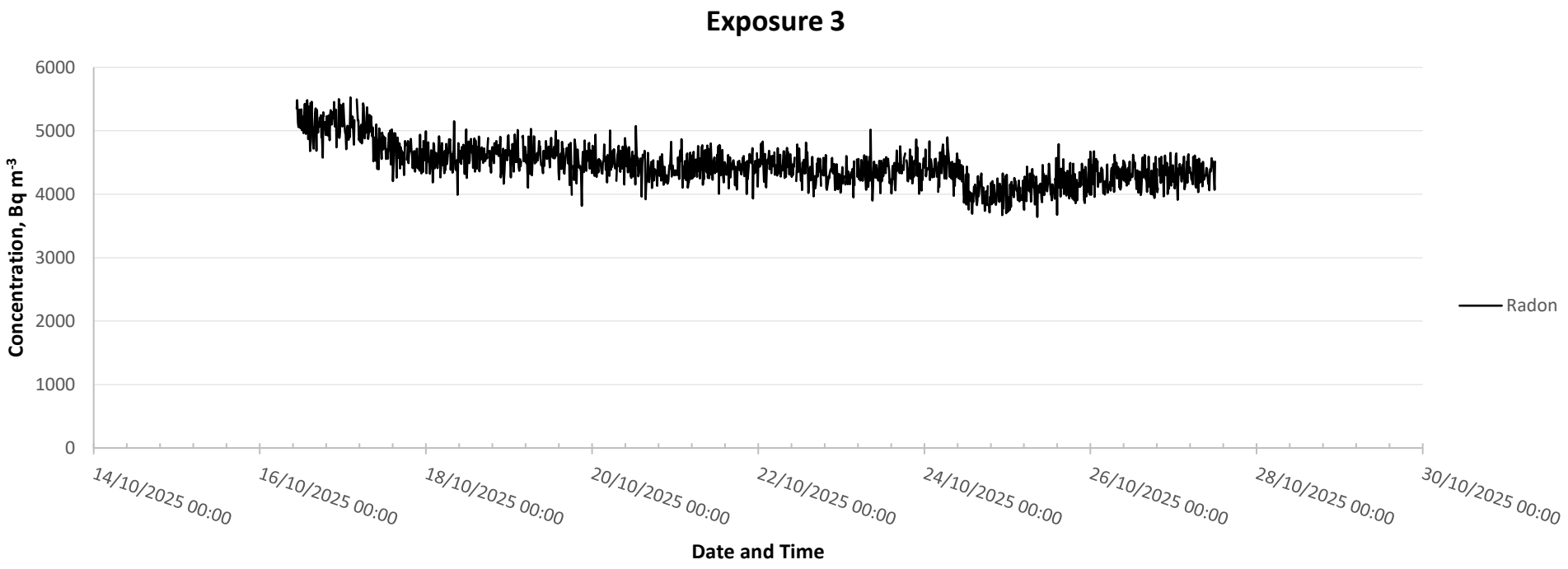
The above figure shows the fluctuation of radon concentration during exposure 1, which covers the period 17 October 2025 to 24 October 2025. The radon concentration initially fluctuated around 4,700 Bq m^{-3} then reduced slightly to around 4,400 Bq m^{-3}.

Figure 2. Radon concentration for exposure 2



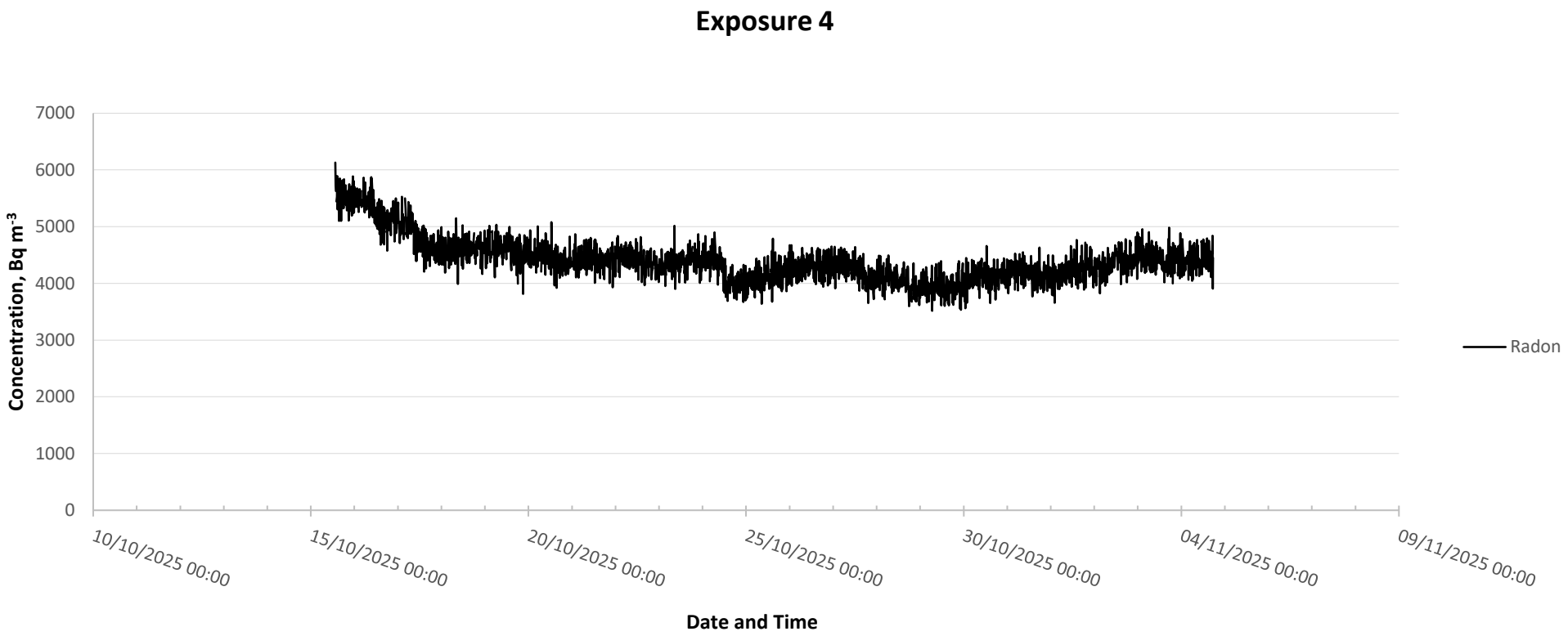
The above figure shows the fluctuation of radon concentration during exposure 2, which covers the period 05 November 2025 to 07 November 2025. The radon concentration fluctuated around 4,000 Bq m^{-3}, then slowly climbed to a peak of around 4,600 Bq m^{-3} and then reduced to around 4,000 Bq m^{-3} with some minor fluctuations. The gaps in the trace line were caused by communication errors between the ATMOS instrument and the data logging system.

Figure 3. Radon concentration for exposure 3



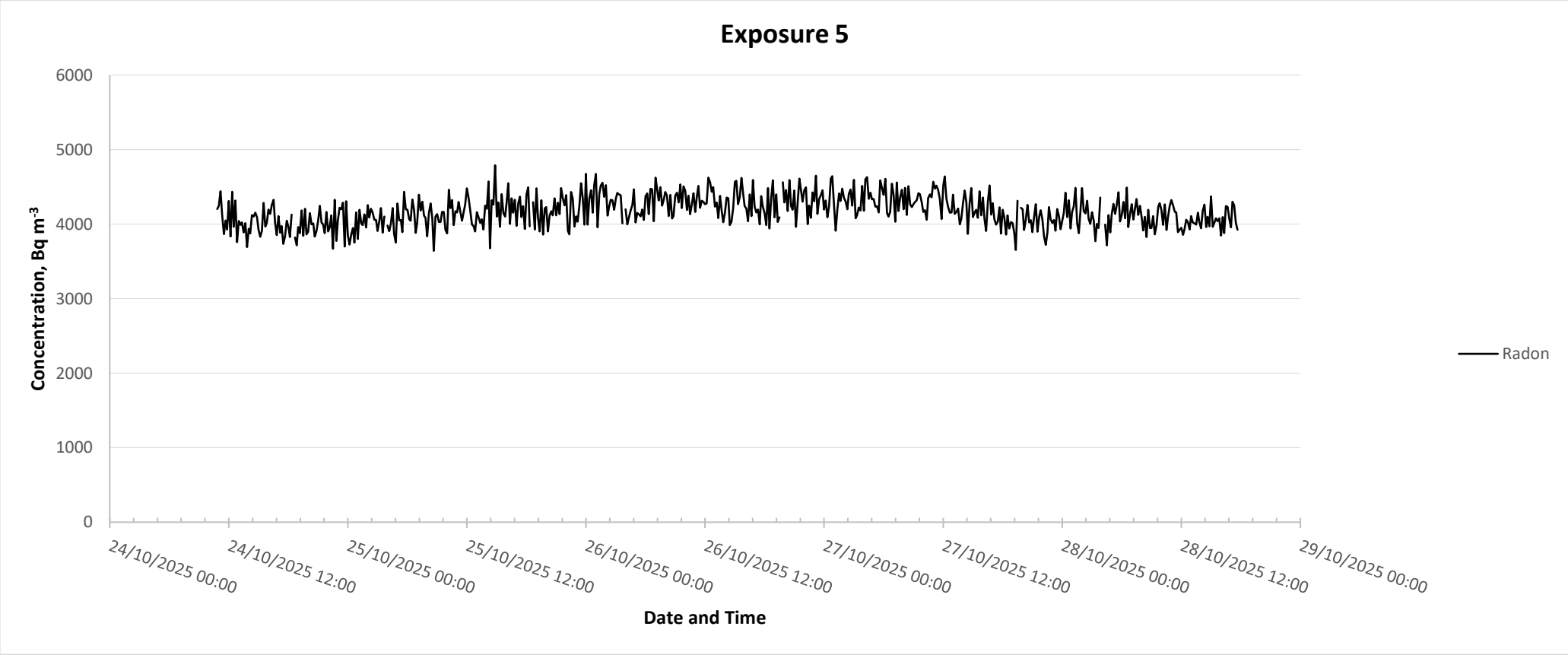
The above figure shows the fluctuation of radon concentration during exposure 3 which covers the period 16 October 2025 to 27 October 2025. The radon concentration began at over 5,000 Bq m^{-3}, with a gradual decline to around 4,500 Bq m^{-3}, then a sudden drop to around 4,000 Bq m^{-3}, with a gradual climb to around 4,300 Bq m^{-3}

Figure 4. Radon concentration for exposure 4



The above figure shows the fluctuation of radon concentration during exposure 4, which covers the period 15 October 2025 to 04 November 2025. The radon concentration began at around 5,500 Bq m^{-3}, reduced, then fluctuated between 4,500 Bq m^{-3} and 4,000 Bq m^{-3}).

Figure 5. Radon concentration for exposure 5



The above figure shows the fluctuation of radon concentration during exposure 5, which covers the period 24 October 2025 to 28 November 2025. The radon concentration initially fluctuated around 4,000 Bq m^{-3}, increased slightly to around 4,300 Bq m^{-3} then dropped, ending at around 4,000 Bq m^{-3}. The gap in the trace line was caused by a communication error between the ATMOS instrument and the data logging system.

Figure 6. Results as reported by participants for exposure 1 - given in Table 4.1

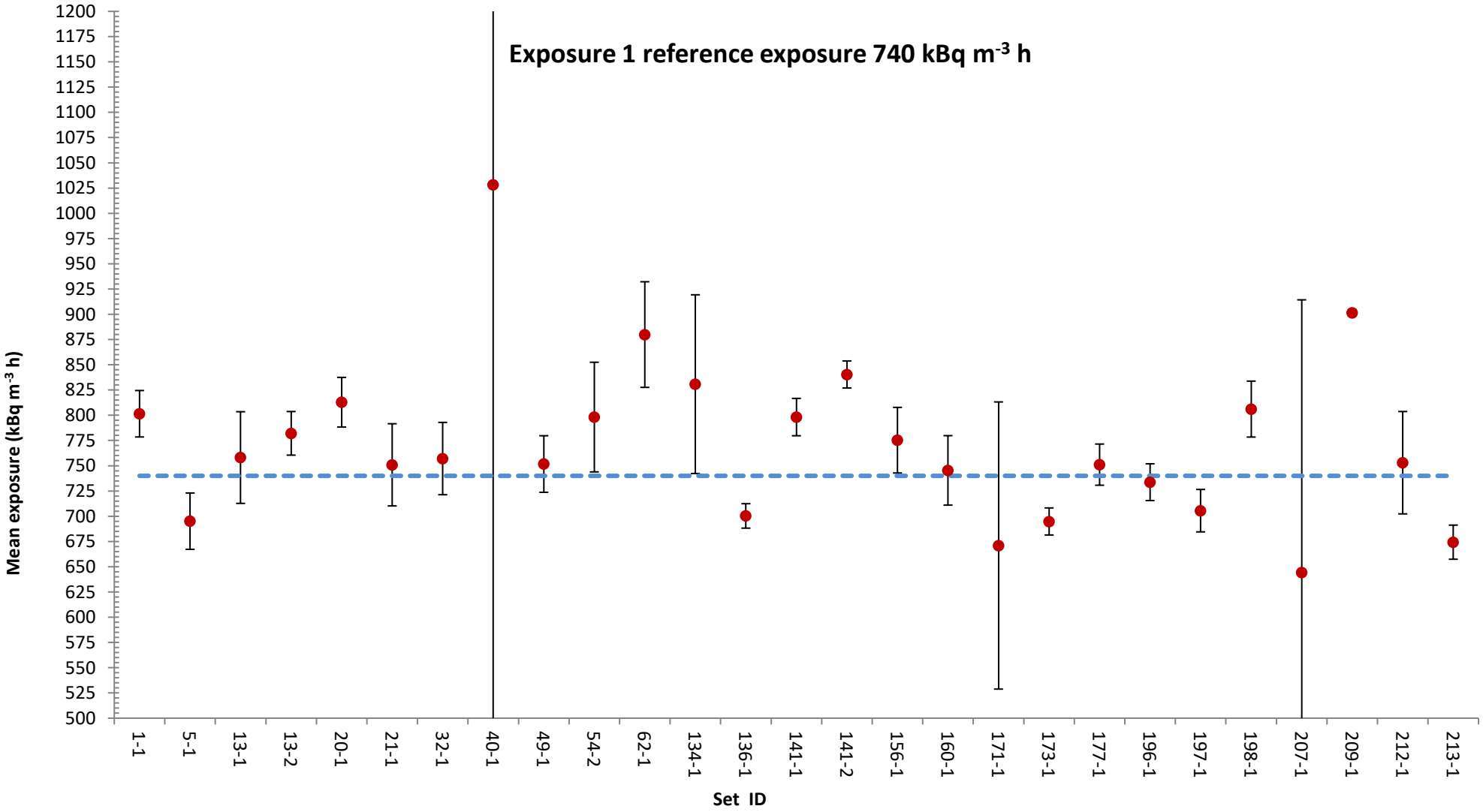


Figure 7. Results as reported by participants for exposure 2 - given in Table 4.2

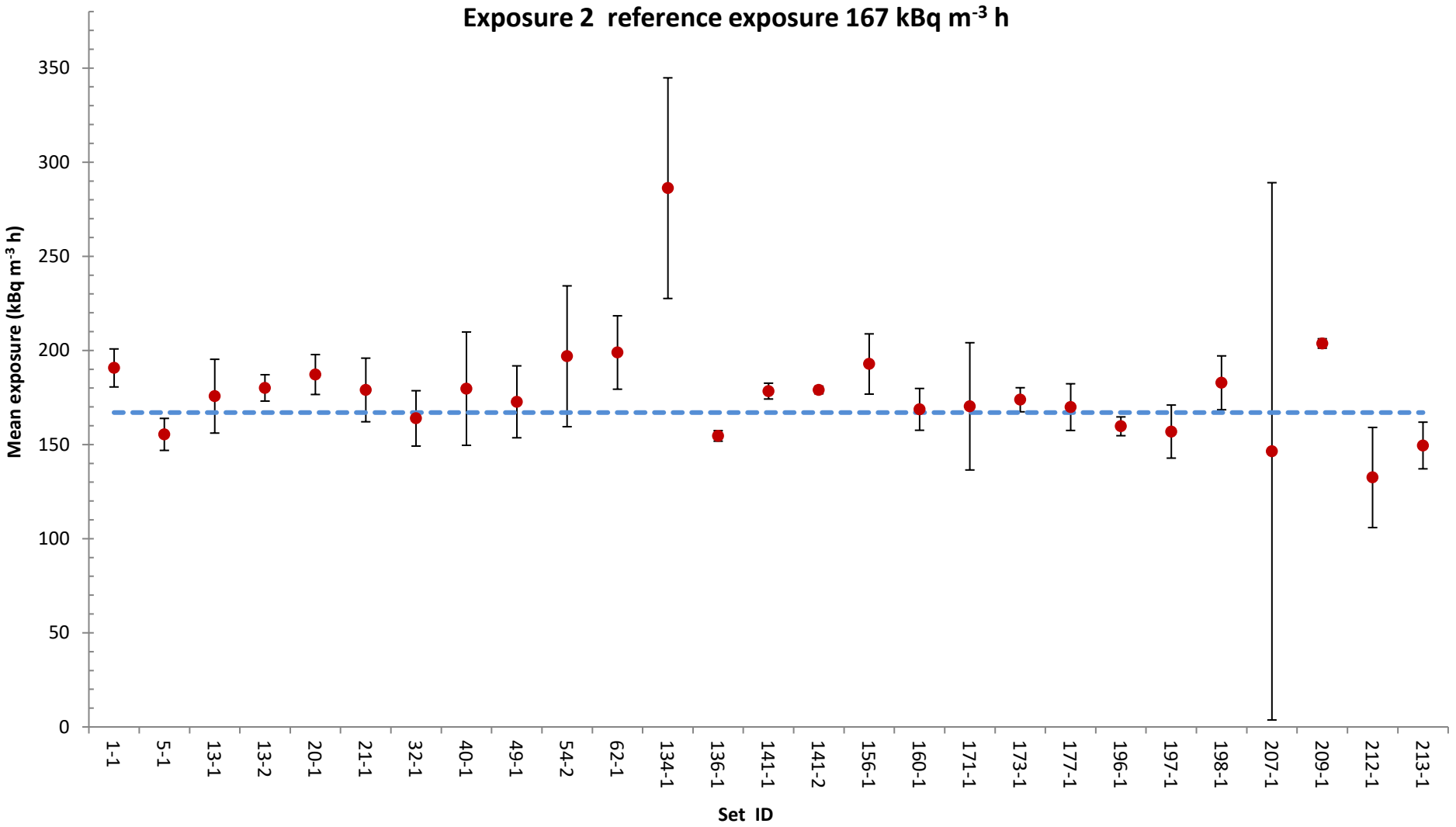


Figure 8. Results as reported by participants for exposure 3 - given in Table 4.3

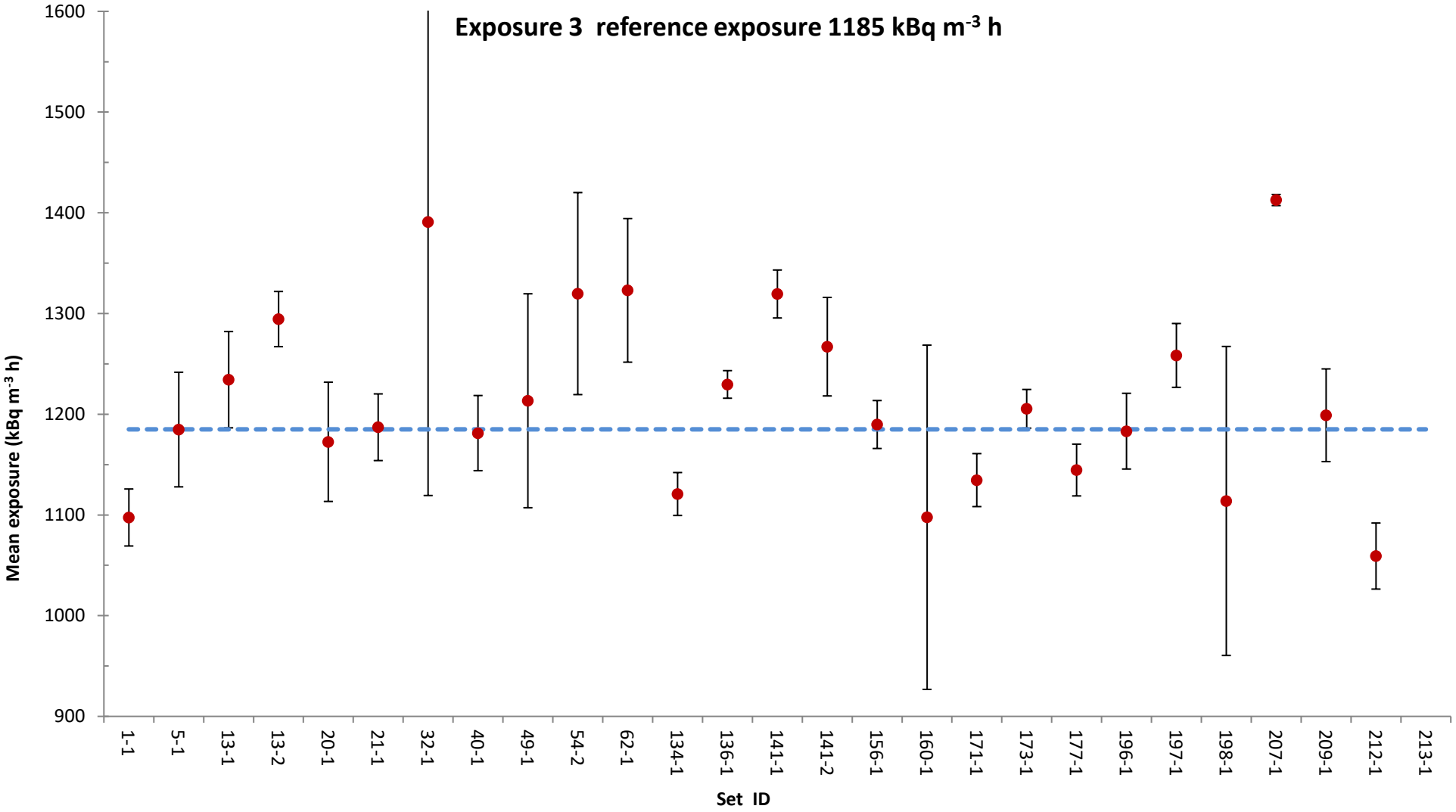


Figure 9. Results as reported by participants for exposure 4 - given in Table 4.4

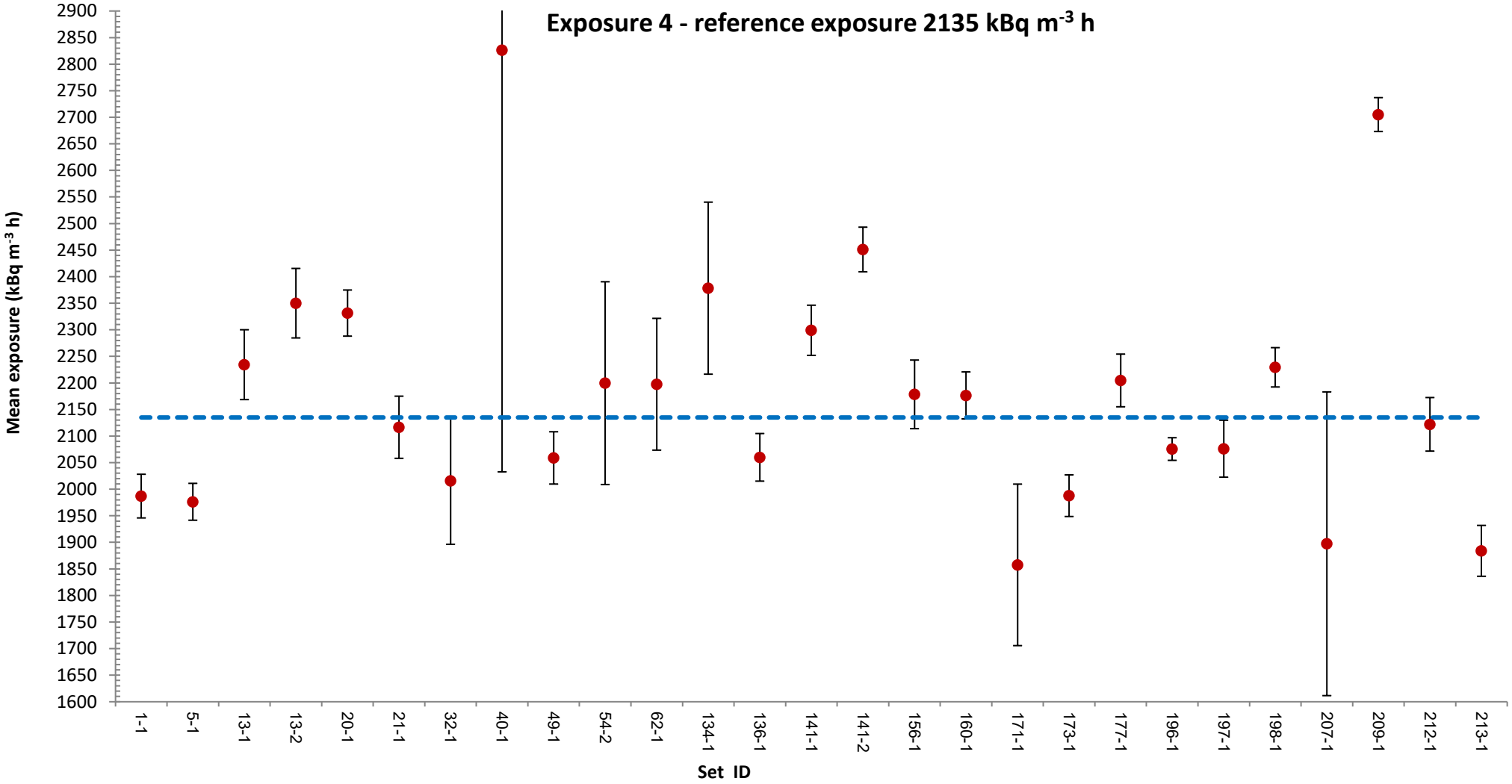


Figure 10. Results as reported by participants for exposure 5 - given in Table 4.5

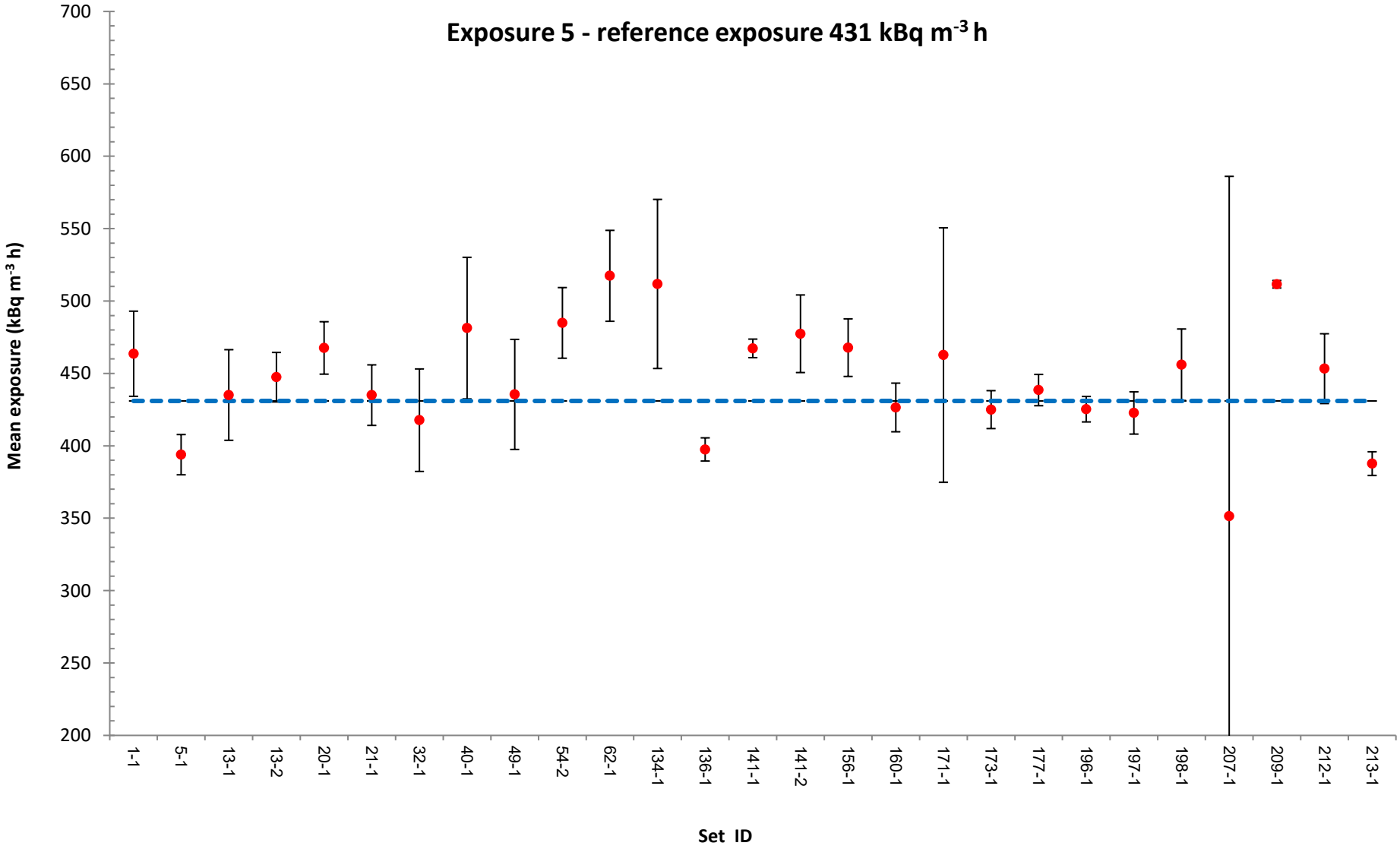


Figure 11. Results as reported by participants for transit exposure - given in Table 4.6

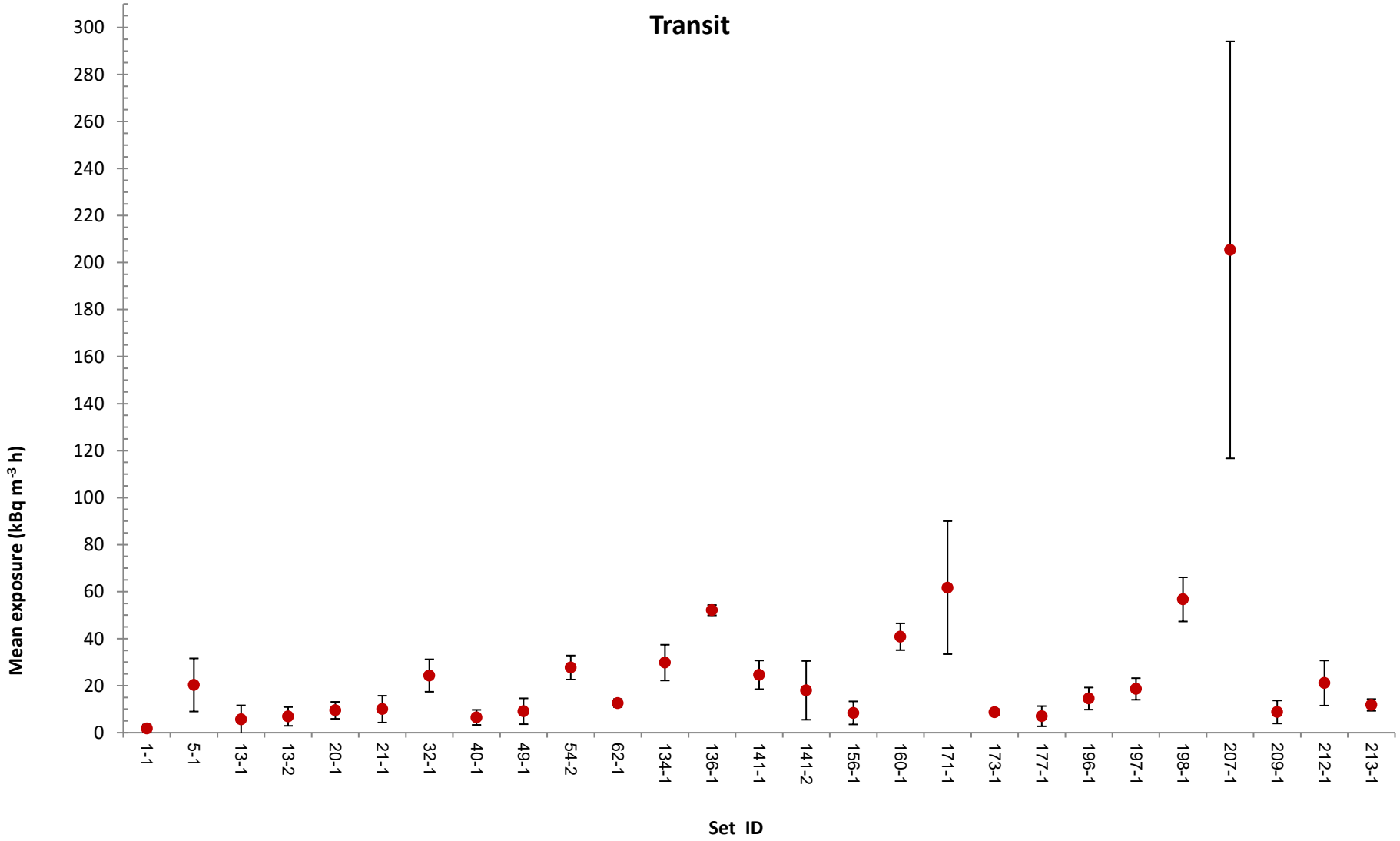


Figure 12. Distribution of mean exposure results for exposure 1 - given in Table 4.1. The vertical dotted line indicates the reference exposure.

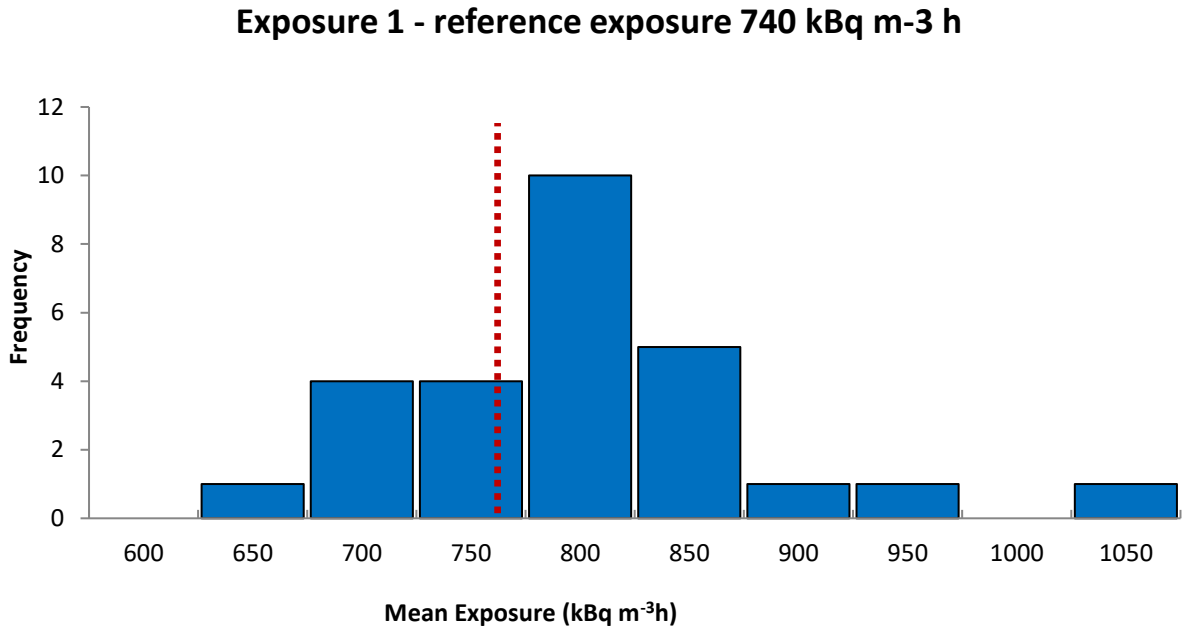


Figure 13. Distribution of mean exposure results for exposure 2 - given in Table 4.2. The vertical dotted line indicates the reference exposure.

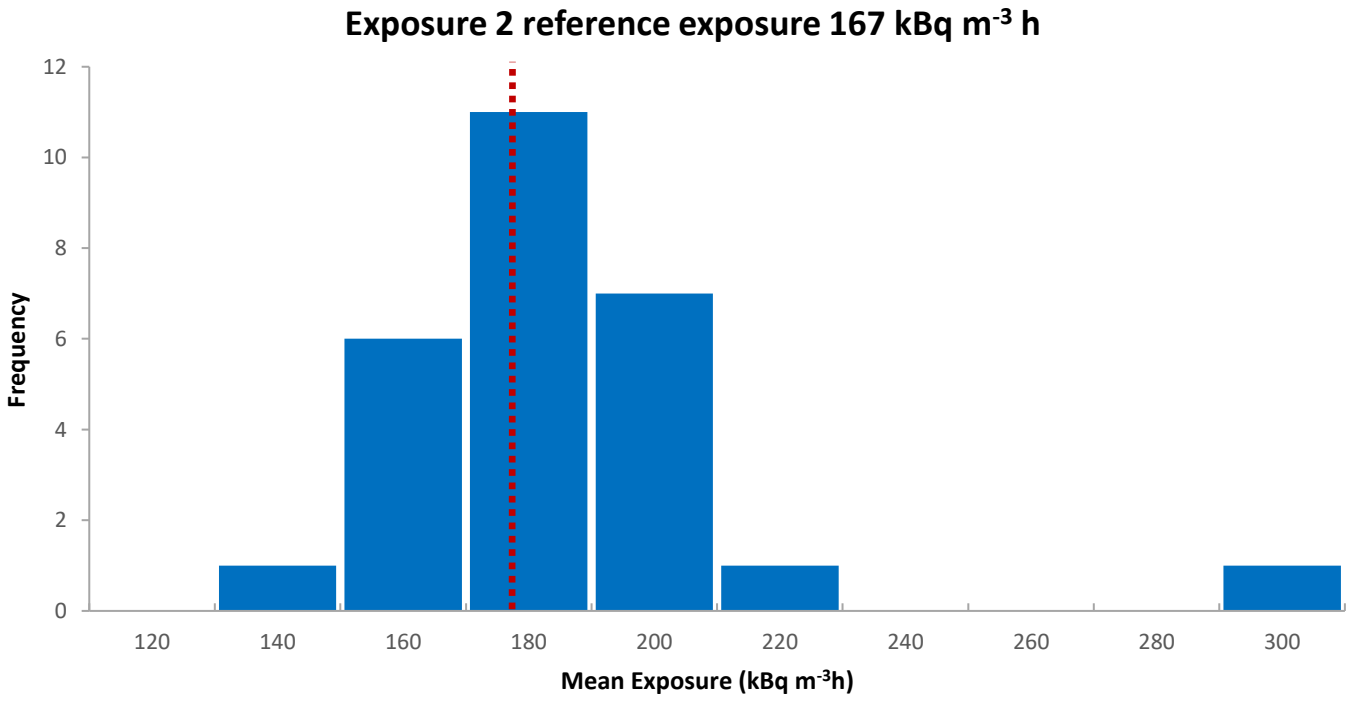


Figure 14. Distribution of mean exposure results for exposure 3 - given in Table 4.3. The vertical dotted line indicates the reference exposure.

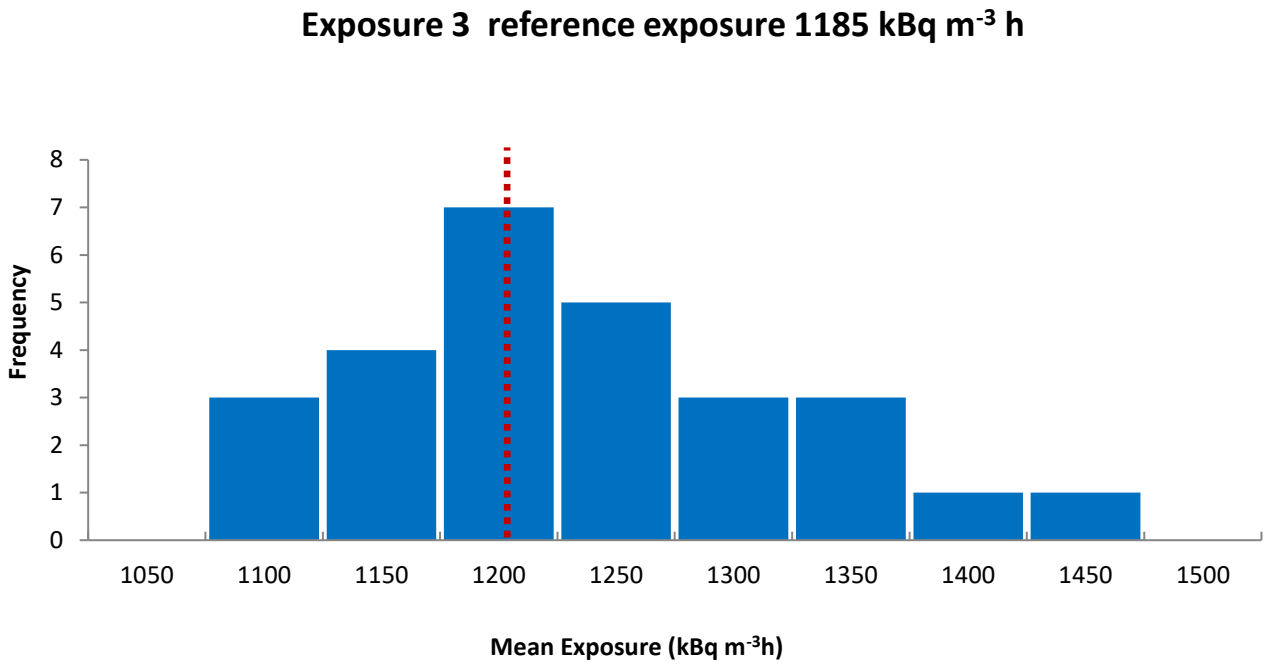


Figure 15. Distribution of mean exposure results for exposure 4 - given in Table 4.4. The vertical dotted line indicates the reference exposure.

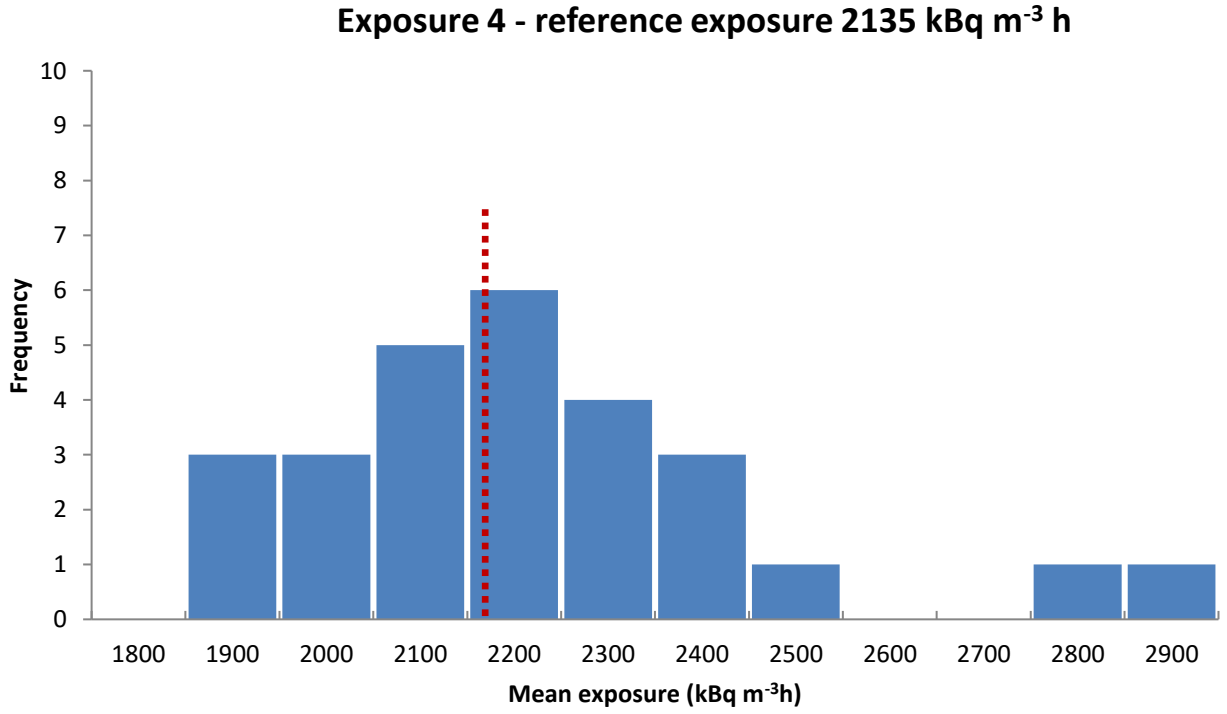


Figure 16. Distribution of mean exposure results for exposure 5 - given in Table 4.5. The vertical dotted line indicates the reference exposure.

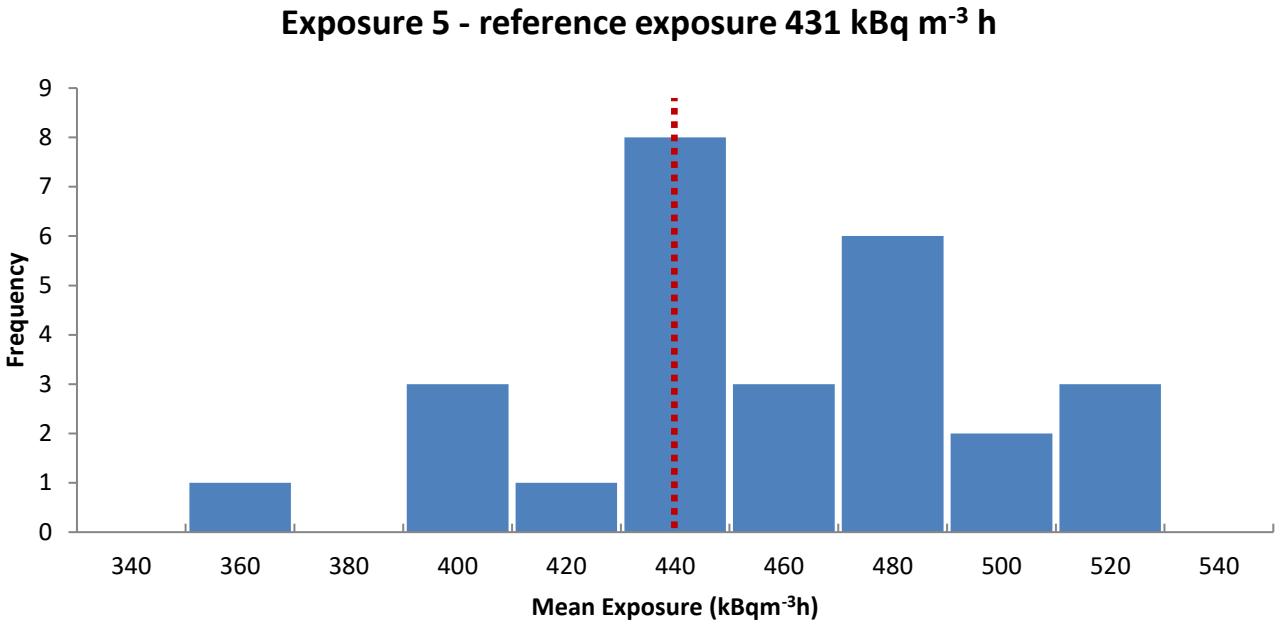


Figure 17. Distribution of mean exposure results for the transit exposure - given in Table 4.6.

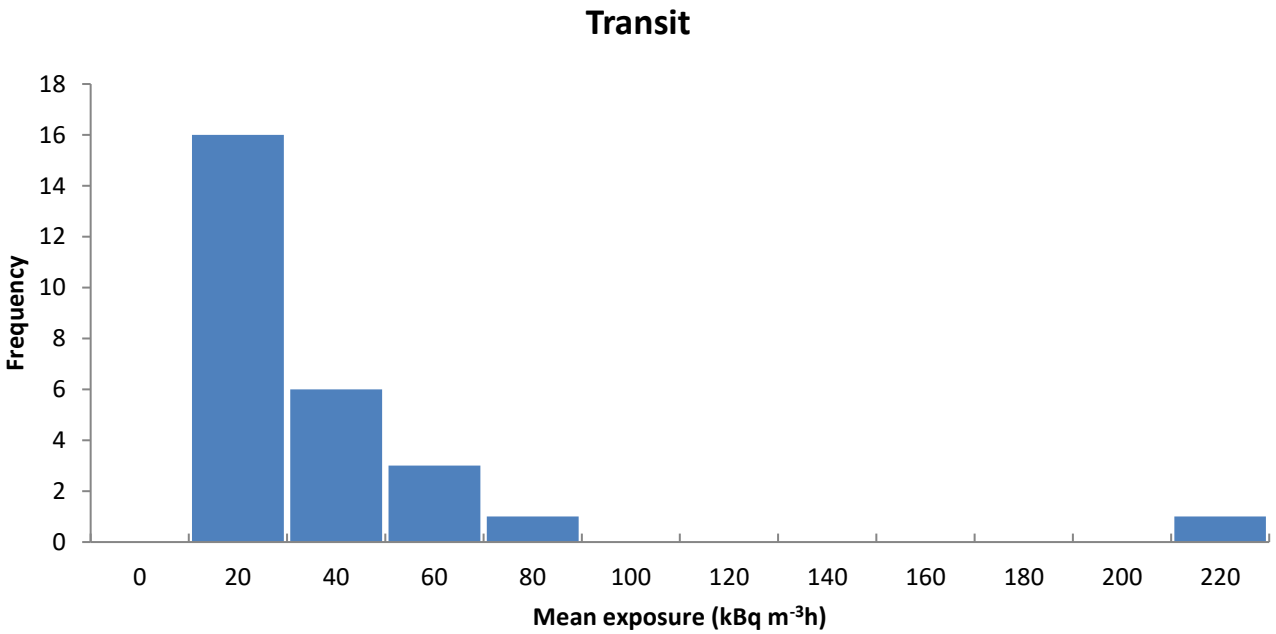


Figure 18. Performance classes for each exposure from A (best) to F (worst) summarised in Table 7 below

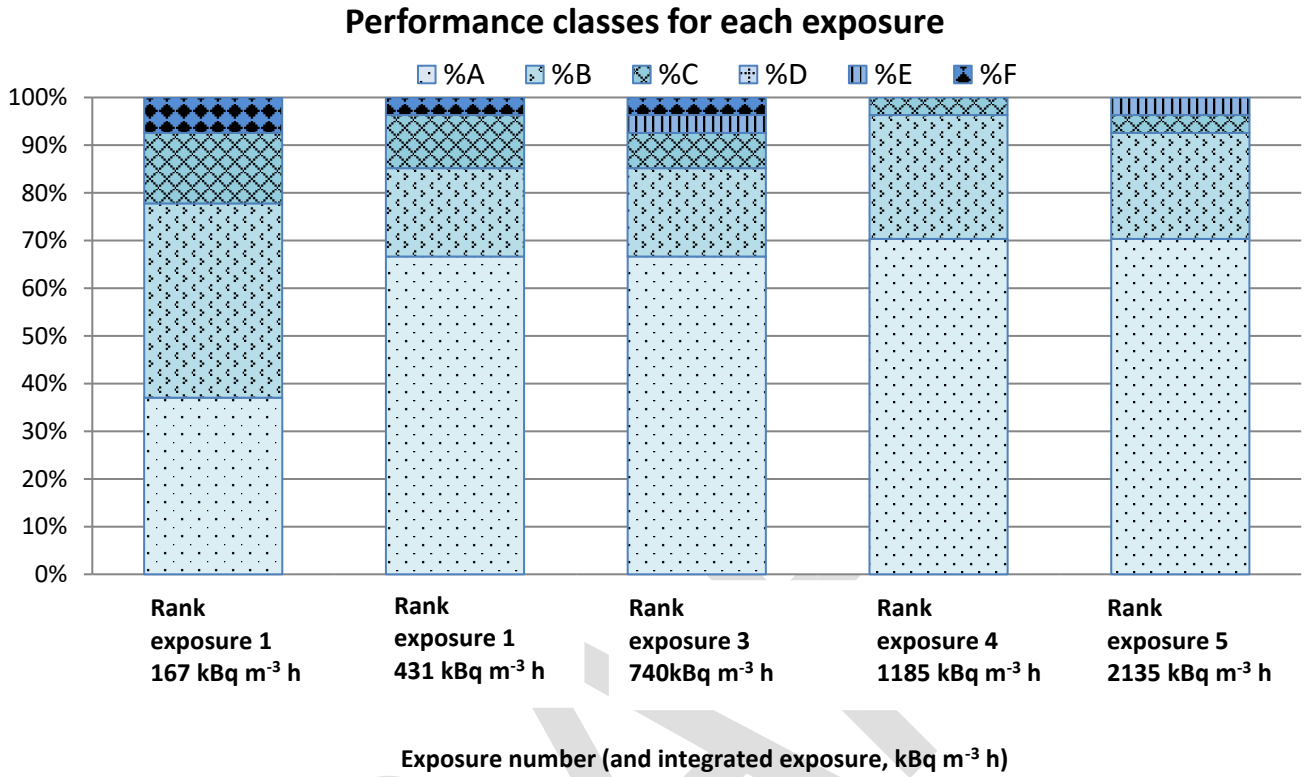


Table 7. Exposure number (and integrated exposure, kBq m^{-3} h)

	Rank exposure 1 167 kBq m^{-3} h	Rank exposure 4 431 kBq m^{-3} h	Rank exposure 2 740 kBq m^{-3} h	Rank exposure 5 1185 kBq m^{-3} h	Rank exposure 3 2135 kBq m^{-3} h
%F	7	4	4	0	0
%E	0	0	4	0	4
%D	0	0	0	0	0
%C	15	11	7	4	4
%B	41	19	19	26	22
%A	37	67	67	70	70

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